Safety Manual

VEGATOR 111, 112

With SIL qualification

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1 Document language

DE	Das vorliegende *Safety Manual* für Funktionale Sicherheit ist verfügbar in den Sprachen Deutsch, Englisch, Französisch und Russisch.
EN	The current *Safety Manual* for Functional Safety is available in German, English, French and Russian language.
FR	Le présent *Safety Manual* de sécurité fonctionnelle est disponible dans les langues suivantes: allemand, anglais, français et russe.
RU	Данное руководство по функциональной безопасности *Safety Manual* имеется на немецком, английском, французском и русском языках.

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2 Scope

2.1 Instrument version

This safety manual applies to signal conditioning instruments

VEGATOR 111, 112

Input signal:

- NAMUR (IEC 60947-5-6)

Valid version:

- from HW Ver 1.0.0

SIL The following functions are excluded from safety-relevant applications:

- Version VEGATOR 111: fail safe relay
- Version VEGATOR 112: two-point control mode

2.2 Area of application

The signal conditioning instruments can be used with a suitable transducer for level detection or range monitoring in a safety-instrumented system in accordance with IEC 61508 in the *low demand mode* or *high demand mode*:

- Up to SIL2 in a single-channel architecture
- Up to SIL3 in a multiple-channel architecture

The following interface should be used to output the measured value:

- Version VEGATOR 111: relay 1
- Version VEGATOR 121: relay 1 or relay 2

SIL In a SIL3 architecture the two channels may not be used redundantly in the VEGATOR 112!

2.3 SIL conformity

The SIL conformity was independently judged and certified by the *TÜV Rheinland* according to IEC 61508:2010 (Ed.2).[1)]

SIL The certificate is valid for the entire service life of all instruments that were sold before the certificate expired!

[1)] Verification documents see appendix

3 Planning

3.1 Safety function

Level detection with VEGATOR 111 or 112

The transducer fed by the signal conditioning instrument generates a signal of > 1.6 mA or < 1.6 mA corresponding to the process variable. A level detection relay is switched dependent on this signal and on the selected mode.

This applies for both channels in the VEGATOR 112 version if the two-point control is not selected.

Mode monitoring with VEGATOR 112

Two transducers fed by the signal conditioning instrument each generates a signal of > 1.6 mA or < 1.6 mA corresponding to the process variable. Two limit values can therefore be measured for range monitoring.

The following points must be observed here:

- The two NO contacts must be connected in series
- Channel for the upper limit: Max. mode
- Channel for the lower limit: Min. mode
- The two-point control may not be selected

3.2 Safe state

Safe state

The safe condition of the output is independent of the mode, by definition the currentless state of the relay (quiescent current principle).

Therefore only the NO contact may be used for safety-relevant applications.

Output signals in case of malfunction

Relay outputs:

- NO contacts open

3.3 Prerequisites for operation

Instructions and restrictions

- The measuring system should suit the application. The application-specific limits must be maintained
- The specifications according to the operating instructions manual, particularly the current load on the output circuits, must be kept within the specified limits
- To avoid a fusing of the relay contacts, these must be protected by an external fuse that triggers at 60 % of the max.contact current load.
- The installation site must comply with IP 54 protection
- The instructions in chapter "*Safety-related characteristics*", paragraph "*Supplementary information*" must be noted
- All parts of the measuring chain must correspond to the planned "*Safety Integrity Level (SIL)*"

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4 Safety-related characteristics

4.1 Characteristics in accordance with IEC 61508 for level detection

VEGATOR 111 or one channel of the VEGATOR 112

Parameter	Value
Safety Integrity Level	SIL2 in single-channel architecture SIL3 in multiple channel architecture[2)]
Hardware error tolerance	HFT = 0
Instrument type	Type A
Mode	Low demand mode, High demand mode
SFF	> 60 %
MTBF[3)]	1.93 x 10^6 h (220 years)
Fault reaction time[4)]	< 2 s

Failure rates

λ_S	λ_{DD}	λ_{DU}	λ_H	λ_L	λ_{AD}	λ_{AU}
170 FIT	29 FIT	46 FIT	0 FIT	0 FIT	0 FIT	19 FIT

PFD_{AVG}	0.038 x 10^{-2}	(T1 = 1 year)
PFD_{AVG}	0.057 x 10^{-2}	(T1 = 2 years)
PFD_{AVG}	0.111 x 10^{-2}	(T1 = 5 years)
PFH	0.046 x 10^{-6} 1/h	

Coverage with the proof test (PTC)

Test type[5)]	Remaining dangerous undetected failures	PTC
Test 1	5 FIT	89 %
Test 2 and 3	2 FIT	96 %

4.2 Characteristics in accordance with IEC 61508 for range monitoring

VEGATOR 112

Parameter	Value
Safety Integrity Level	SIL2 in single-channel architecture SIL3 in multiple channel architecture[6)]

2) Homogeneous redundancy possible (see note in the section "Area of Applicaton").
3) Including errors outside the safety function.
4) Time between the occurrence of the event and the output of a fault signal.
5) See section "Proof test".
6) Homogeneous redundancy possible.

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Parameter	Value
Hardware error tolerance	HFT = 0
Instrument type	Type A
Mode	Low demand mode, High demand mode
SFF	> 60 %
MTBF[7]	1.65 x 10^6 h (188 years)
Fault reaction time[8]	< 2 s

Failure rates

λ_S	λ_{DD}	λ_{DU}	λ_H	λ_L	λ_{AD}	λ_{AU}
240 FIT	44 FIT	74 FIT	0 FIT	0 FIT	0 FIT	35 FIT

PFD_{AVG}	0.062 x 10^{-2}	(T1 = 1 year)
PFD_{AVG}	0.091 x 10^{-2}	(T1 = 2 years)
PFD_{AVG}	0.178 x 10^{-2}	(T1 = 5 years)
PFH	0.074 x 10^{-6} 1/h	

Coverage with the proof test (PTC)

Test type[9]	Remaining dangerous undetected failures	PTC
Test 1	8 FIT	89 %
Test 2 and 3	2 FIT	97 %

4.3 Figures according to ISO 13849-1

Derived from the safety-related characteristics, the following figures result according to ISO 13849-1 (machine safety):[10]

Level detection with VEGATOR 111 or one channel of the VEGATOR 112

Parameter	Value
MTTFd	1522 years
DC	38 %
Performance Level	4.61 x 10^{-8} 1/h (corresponds to "e")

Range monitoring with VEGATOR 112

Parameter	Value
MTTFd	970 years
DC	37 %
Performance Level	7.38 x 10^{-8} 1/h (corresponds to "e")

[7] Including errors outside the safety function.
[8] Time between the occurrence of the event and the output of a fault signal.
[9] See section "Proof test".
[10] ISO 13849-1 was not part of the certification of the instrument.

4.4 Supplementary information

Determination of the failure rates

The failure rates of the instrument were determined by an FMEDA according to IEC 61508. Basis for the calculations are the component failure rates according to **SN 29500**.

All figures refer to an average ambient temperature of 40 °C (104 °F) during the operating time. For higher temperatures, the values should be corrected:

- Continuous application temperature > 50 °C (122 °F) by factor 1.3
- Continuous application temperature > 60 °C (140 °F) by factor 2.5

Similar factors apply if frequent temperature fluctations are expected.

Assumptions of the FMEDA

- The failure rates are constant. Take note of the useful service life of the components according to IEC 61508-2.
- Multiple errors are not taken into account
- Wear on mechanical parts is not taken into account
- Failure rates of external power supplies are not taken into account
- The environmental conditions correspond to an average industrial environment
- To avoid a fusing of the relay contacts, these must be protected by an external fuse

Calculation of PFD_{AVG}

The values for PFD_{AVG} specified above were calculated as follows for a 1oo1 architecture:

$$PFD_{AVG} = \frac{PTC \times \lambda_{DU} \times T1}{2} + \lambda_{DD} \times MTTR + \frac{(1 - PTC) \times \lambda_{DU} \times LT}{2}$$

- T1 (Proof Test Interval)
- MTTR = 8 h
- PTC = 90 %
- LT = 10 years

Multiple channel architecture

In multiple channel systems for SIL3 applications, this measuring system can also be used in a homogeneously redundant configuration.

The safety-related characteristics must be calculated especially for the selected structure of the measuring chain using the stated failure rates. In doing this, a suitable Common Cause Factor must be considered (see IEC 61508-6, appendix D).

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5 Setup

5.1 General information

Mounting and installation

Take note of the mounting and installation instructions in the operating instructions manual.

5.2 Adjustment instructions

Adjustment elements

The operating elements must be set according to the application. The function of the operating elements as well as the parameter adjustment procedure are described in the operating instructions.

SIL The safety function must be considered unsafe during the setting process! Other actions must be taken to maintain the safety function if necessary.

SIL With regard to the switch on/swich off delay it must be ensured that the sum of all switching delays from the transducer to the actuator is adapted to the process safety time!

SIL The instrument must be protected against inadvertent or unauthorized operation!

6 Diagnostics and service

6.1 Behaviour in case of failure

Internal diagnosis

The instrument is permanently monitored by an internal diagnostic system. If a malfunction is detected, the respective output signals change to the status configured especially for this condition (see section "*Safe status*").

Error messages

The occurrence of an error is signalled by the red LED and, if necessary, by the fail safe relay.

6.2 Repair

Reaction when malfunctions occur

If faults are detected, the entire measuring system must be shut down and the process held in a safe state by other measures.

The manufacturer must be informed of the occurrence of a dangerous, undetected error (incl. fault description).

7 Proof test

7.1 General information

Objective

To identify possible undetected, dangerous failures, the safety function must be checked by a proof test at adequate intervals. It is the user's responsibility to choose the type of testing. The time intervals are subject to the PFD_{AVG} in chapter "*Safety-related characteristics*").

For documentation of these tests, the test protocol in the appendix can be used.

If one of the tests proves negative, the entire measuring system must be switched out of service and the process held in a safe state by means of other measures.

In a multiple channel architecture this applies separately to each channel.

Preparation

- Determine safety function (mode, switching points)
- If necessary, remove the instruments from the safety chain and maintain the safety function by other means

Unsafe device status

Warning:
During the function test, the safety function must be treated as unreliable. Take into account that the function test influences downstream connected devices.

If necessary, you must take other measures to maintain the safety function.

After the function test, the status specified for the safety function must be restored.

7.2 Test 1 - without input current simulation

Conditions

- Use of any transducer
- Output signals correspond to the current limit level

Procedure

1. Push the min./max. switch on the VEGATOR 111, 112
2. Check relay contacts

Expected result

- about 1: Relay and LED display change states
- about 2: Relay contacts open and close according to item 1

Coverage of the test

See *Safety-related characteristics*

7.3 Test 2 - with input current simulation

Conditions

- Possibility of sensor current simulation exists
- Output signals correspond to the current limit level

Procedure

1. Invert sensor current by means of the min./max. switch on the transducer (2.1 mA/1.2 mA)
2. Check relay contacts

Expected result

- about 1: State of relay and LED display follow the simulated sensor current
- about 2: Relay contacts open and close according to item 1

Coverage of the test See *Safety-related characteristics*

7.4 Test 3 - with switch-on pulse checking

Conditions

- Use of a VEGAVIB 60 or VEGAWAVE 60 transducer with NAMUR output
- Output signals correspond to the current limit level

Procedure

1. Press test key
2. Check relay contacts

Expected result

- about 1: State of relay and LED display follows the switch-on pulse (the curve of the switch-on pulse is described in the transducer operating instructions)
- about 2: Relay contacts open and close according to item 1

Coverage of the test See *Safety-related characteristics*

8 Appendix A - Test report

Identification	
Company/Tester	
Plant/Instrument TAG	
Meas. loop TAG	
Instrument type/Order code	
Instrument serial number	
Date, setup	
Date, last function test	

Test reason		Test scope	
(…)	Setup	(…)	without input current simulation
(…)	Proof test	(…)	with input current simulation
		(…)	with switch-on pulse checking

Mode		Delay times	
Max.	Channel 1 (…); channel 2 (…)	(…)	Switch-on delay
Min.	Channel 1 (…); channel 2 (…)	(…)	Switch-off delay
(…)	Range monitoring		

Test result for test 1 and 2

Limit level signal Channel 1	Min./Max. switch channel 1	Condition Relay 1	Limit level signal Channel 2	Min./Max. switch channel 2	Condition Relay 2	Test result

Test result for test 3

Limit level signal Channel 1	State function test	Condition Relay 1	Limit level signal Channel 2	State function test	Condition Relay 2	Test result
	Empty signal			Empty signal		
	Full signal			Full signal		

Confirmation	
Date:	Signature:

9 Appendix B - Term definitions

Abbreviations

SIL	Safety Integrity Level
HFT	Hardware Fault Tolerance
SFF	Safe Failure Fraction
PFD_{AVG}	Average Probability of dangerous Failure on Demand
PFH	Average frequency of a dangerous failure per hour (Ed.2)
FMEDA	Failure Mode, Effects and Diagnostics Analysis
FIT	Failure In Time (1 FIT = 1 failure/10^9 h)
λ_{SD}	Rate for safe detected failure
λ_{SU}	Rate for safe undetected failure
λ_S	$\lambda_S = \lambda_{SD} + \lambda_{SU}$
λ_{DD}	Rate for dangerous detected failure
λ_{DU}	Rate for dangerous undetected failure
λ_H	Rate for failure, who causes a high output current (> 21 mA)
λ_L	Rate for failure, who causes a low output current (≤ 3.6 mA)
λ_{AD}	Rate for diagnostic failure (detected)
λ_{AU}	Rate for diagnostic failure (undetected)
DC	Diagnostic Coverage
PTC	Proof Test Coverage
T1	Proof Test Interval
LT	Useful Life Time
MTBF	Mean Time Between Failure
MTTF	Mean Time To Failure
MTTR	Mean Time To Restoration (Ed.2)
$MTTF_d$	Mean Time To dangerous Failure (ISO 13849-1)
PL	Performance Level (ISO 13849-1)

10 Supplement C - SIL conformity

Certificate

TÜVRheinland CERTIFIED
Functional Safety Type Approved
www.tuv.com
ID 0600000000

Nr./No.: 968/FSP 1025.00/14

Prüfgegenstand **Product tested**	Auswertgerät VEGATOR Serie 100 Signal conditioning instrument VEGATOR 100 Series	**Zertifikats-inhaber** **Certificate holder**	VEGA Grieshaber KG Am Hohenstein 113 77761 Schiltach Germany
Typbezeichnung **Type designation**	VEGATOR 111/112 (NAMUR)		
Prüfgrundlagen **Codes and standards**	IEC 61508 Parts 1-7:2010 IEC 61511-1:2003 + Corr. 1:2004	IEC 61010-1:2010 IEC 61326-3-2:2008	
Bestimmungsgemäße Verwendung **Intended application**	Auswertgerät zur Grenzstanderfassung. Die Auswertgeräte der VEGATOR Serie 100 erfüllen die Anforderungen der genannten Prüfgrundlagen und können in einem sicherheitsbezogenen System gemäß IEC 61508 eingesetzt werden, in HFT=0 Struktur bis SIL 2 und redundant (HFT=1) bis SIL 3. Signal conditioning instrument for level detection. The signal conditioning instruments of the VEGATOR 100 Series comply with the requirements of the stated standards and can be used in a safety-related system acc. IEC 61508, in HFT=0 configuration up to SIL 2 and redundant (HFT=1) up to SIL 3.		
Besondere Bedingungen **Specific requirements**	Die zugehörigen Betriebsanleitungen und das Safety Manual sind zu beachten. The operating instructions and the safety manual shall be considered.		

Gültig bis / Valid until 2019-09-22

Der Ausstellung dieses Zertifikates liegt eine Prüfung zugrunde, deren Ergebnisse im Bericht-Nr. 968/FSP 1025.00/14 vom 22.09.2014 dokumentiert sind.
Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen. Es wird ungültig bei jeglicher Änderung der Prüfgrundlagen für den angegebenen Verwendungszweck.
The issue of this certificate is based upon an examination, whose results are documented in report-no.: 968/FSP 1025.00/14 dated 2014-09-22.
This certificate is valid only for products which are identical with the product tested. It becomes invalid at any change of the codes and standards forming the basis of testing for the intended application.

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Köln, 2014-09-22
Certification Body for FS-Products
Dipl.-Ing. Heinz Gall

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